marble as the parent mass from whence it was broken and abraded; he gains no information into the things of which it is made; he therefore resorts to the means and appliances of his own well-furnished laboratory, and seeks for some chemical agent that will unbind the particles of the marble, and display the secrets of its composition.

Fire is a grand and powerful agent in the chemical laboratory for extorting a confession from substances, as to their composition, and indeed so constant is its employment, that the chemist is often designated as "the philosopher by fire," his working motto was "*sine igne nihil operamur*," and although the progress of research has proved the necessity of numberless agents besides fire, it is still perfectly indispensable in chemical operations, and in many instances it will effect the decomposition of substances, placed within its power. Suppose then, the chemist take fifty parts by weight (for by weight he exclusively works), of pure Carrara marble, and place it in a crucible, and subject it to the bright red heat of a furnace for some hours, then withdraw the crucible, allow it to cool, and examine its contents. He finds that the heat has not dissipated the marble, or at all events there is a white solid substance in the crucible apparently about the same bulk as the original marble, but removing this carefully and appealing again to the balance, he finds a deficiency in weight amounting to twenty-two parts, and yet he is certain that no portion of the original marble has accidentally fallen out of the crucible during the exposure to the furnace fire. He notes this deficiency in weight, he repeats the experiment again and again, and invariably finds that fifty parts of pure Carrara marble lose twenty-two parts, or in other words that only twenty-eight parts of a white fixed substance remain in the crucible; by this proceeding he has established an *experimental fact*, and it admits of verification by any person who will take the requisite care in accurately weighing the marble before and after its exposure to the heat of the furnace.

The loss of weight is beyond doubt, but submitting to it for a time as demanding a searching investigation hereafter, the chemist directs his attention to the twenty-eight parts of solid matter in the crucible, asking the question, "is this still marble?" He knows that marble is perfectly tasteless, that it does not absorb water, but he finds that if he place a minute particle of the fixed residue upon the tongue, that it is excessively caustic and acrid, and if he pour a small quantity of water upon a larger portion of the residue, both it and the water, from being originally cold, become most intensely hot. The residue, then, evidently cannot be marble, but is probably one of its constituents or components, and by following up the above simple trials of taste, and the action of water, with more accurate trials or *tests* (the action of which need not be here particularly specified), the chemist at length infers that the white fixed residue is identical, in all its characters and properties, with a substance universally known as *pure* or *quick lime*. Then comes the question, "have the original fifty parts of marble derived causticity or acrimony from the burning fuel, or has the heat changed or transmuted the marble into quicklime?" The first part of this question carries with it an obvious answer, viz., "there is a deficiency of twenty-two parts, and therefore nothing can have been derived from the fire; and in answer to the second part, the chemist does not entertain the idea of a transmutation, but deems it far more probable that the fixed residue is really one of the constituents of the marble, forced from its union with another of volatile nature by the heat of the furnace. He therefore repeats the experiment again, intently watching the crucible, but can discover nothing escaping from it, although at the close of the operation he still finds twenty-two parts by weight deficient. The chemist now concludes that the matter volatilized by the fire must be of some highly attenuated nature, and probably resembling the air in its physical characters and habitudes, and knowing that bubbles of air will easily rise through water (as when air is blown from the mouth through a straw dipped into water), he modifies the apparatus in which he next intends to submit the marble to heat, so that the volatile or aërial matter as it is expelled may be collected and examined as follows:—

The powdered marble is introduced into an earthenware retort. The bulb of this is placed in the fire, whilst the neck or beak protruding from the fire is dipped beneath the surface of water contained in a basin or small trough. As the bulb becomes hot, numerous bubbles of air rise from the beak through the water, and by filling a large wide mouthed vial with water, and then inverting its neck beneath that contained in the basin or trough (exactly the same as the long necked glass globe of a bird fountain is inverted into the water of its cistern), the neck is carefully raised above the beak of the retort, so that the bubbles of aëriform matter now rise through the water in the bottle, whilst a corresponding portion of water descends from it into the basin or trough.

The heat is continued until the bubbles cease to be emitted, and then by corking the bottle whilst its neck is under water, the aëriform matter is confined, and by placing the bottle in its ordinary position upon a table, its contents can be examined. The aëriform matter thus extricated from the marble, is transparent and invisible as the air itself, but upon withdrawing the cork of the bottle, and quickly introducing a small lighted taper, its flame is instantly extinguished; now it would continue for a certain time in a similar sized vial, containing a similar quantity or volume of air, so this simple test by flame proves the substance in question to differ from air in one of its characters, though it resembles it in the two others above named, and by pursuing the investigation with other tests, the theory of whose action will be fully detailed hereafter, the chemist is led to conclude that the aëriform matter expelled from the marble by the action of heat is identical with that which exists in common soda-water, and it is known by the name of *carbonic-acid gas*. Here then the chemist has effected an analysis of the marble, and modifying the apparatus, the agents of decomposition, and so forth, he finds that in all cases fifty parts of marble will invariably yield twenty-eight parts of lime and twenty-two parts of carbonic-acid gas; for it, although a gas, can be confined, weighed, and measured with the same facility as the solid lime.

But the chemist is not yet satisfied, he next reasons thus, "as I can obtain only these two things from the marble, are they its true constituents? if so, it is extremely probable that when they are mutually presented to each other *attraction of composition* should ensue, and marble should be produced. He therefore proceeds to the operation of *synthesis*, the very reverse of *analysis*, and finds that if he dissolve lime in water, so as to form a perfectly transparent liquid, upon pouring a quantity of this into the vial containing *carbonic acid gas*, that the materials instantly become milk white, that in the course of a short time a white sediment is found at the bottom of the vial, and upon analysing it, *quicklime* and *carbonic acid* are again presented in the proportions by weight of twenty-eight of the former to twenty-two of the latter, exactly as they were presented by the original marble. He finds that this newly and artificially formed sediment or *precipitate* as it is technically called in allusion to its *falling*, is chemically identical with *marble*, but mechanically or physically differing from it, inasmuch as it is soft and pulverulent, instead of having a granularly foliated texture; but even this he can confer by ramming the precipitate tightly in a crucible, then perfectly closing its aperture, and exposing it to an intense heat.

Thus, the chemist can not only decompose natural marble, but he can form artificial marble, in virtue of the laws which govern *attraction of composition*, or, as it is more commonly and conveniently called in the laboratory, *chemical affinity*; and to denote in precise terms the composition of marble, he calls it *carbonate of lime*. But these two new substances, *carbonic acid* and *lime*, do they in their turn admit of decomposition or analysis?

The chemist, by very refined and highly powerful agents, proves that they may be analysed, and that carbonic acid consists of charcoal or *carbon*, and a gas called *oxygen*; the former a black, brittle, combustible substance; the latter an invisible gas, incombustible, but capable of supporting combustion; that *lime* also yields *oxygen*, and a combustible metal of silvery splendour, named *calcium*; so that *lime* is no longer called an *earth*, in strict chemical nomenclature, but an *oxide of calcium*, or, in familiar language, it may be called a *rust*, for common rust is a compound of oxygen and iron.

Throughout all these trials or experiments regarding quantitative analysis, the balance is appealed to at every step; the chemist finds that six parts of *carbon* combine with sixteen parts of *oxygen* to form twenty-two parts of *carbonic acid*; and that twenty parts of *calcium* combine with eight parts of *oxygen* to form twenty-eight parts of *lime*; and that these twenty-two parts of carbonic acid, and twenty-eight parts of lime, will combine to produce fifty parts of carbonate of lime. He has no power over the attraction of composition to force these substances to combine in any other than their unerring, their definite weights; and it matters not in what climate, or at what season, the experiment be made.

The *carbonic acid* and *lime*, yielded by the marble during the foregoing simple analysis, are called its *proximate elements*, because they are *nearest* to, or *first* come to, the hand of the chemist, and will immediately, when presented to each other, combine to produce the marble or the carbonate of lime, whilst the *carbon*, *oxygen*, and *calcium*, yielded by the more complicated or refined analysis, are called the *ultimate elements* of the marble, because, in the present state of chemistry, they do not admit of analysis or simplification. They, and some others to be named, are barriers opposed to the progress of analysis.

In former ages, the term *element* was used to denote *absolute simplicity*. Thus, Air, Earth, Water, and Fire were deemed absolutely *simple*, and capable of forming all other bodies by their mutual admixture or combination. This doctrine was long entertained by philosophers, and has only been abandoned within the last century.

Thus, every variety of aëriform matter was looked upon as of the same nature as the Air around us. Under the general term Earth were classed all substances which remained fixed and unburnt in the most intense fires of the furnace. Water was regarded as a substance neither compoundable nor destructible by any operations; and Fire was deemed to be a peculiar form of matter, having the power of destroying.

But the modern chemist, setting aside theory and hypothesis as of little or no value, and abiding exclusively by the test of experiment, has proved that Air consists of two gases, viz., *oxygen* and *nitrogen*; that Water also consists of two gases, viz., *oxygen* and *hydrogen*; that the various earths consist of *oxygen* and *metals*; and, lastly, that Fire is the common result of intense chemical affinity between two or more substances. Constantly experimenting upon the various forms of matter presented throughout the wide realms of nature, and the limited provinces of art, constantly inquiring regarding *attraction of composition*, the occupation of the chemist is one of pleasure and satisfaction, for in the generality of cases he finds the newly-elicited facts are not only inherently interesting, but susceptible of important and useful applications in the interpretation of natural phenomena, and in aiding the progress of the arts and sciences.

In the science of chemistry at the present day all substances that can be analysed, *ex. gr.*, such as marble, carbonic acid, and lime, are called *compounds*, whilst all substances that resist this treatment, *ex. gr.*, such as oxygen, carbon, and calcium are called *elements*. This term being used to denote substances which may not be absolutely undecomposable, but which at present remain undecomposed. The attraction of composition or the affinity that holds their two or more components together being superior to the power of any decomposing agents that can be found in the chemical laboratory.

There are no less than fifty-five refractory substances which defy analysis; they present types of the three physical forms of matter, viz., the solid, the liquid, and the aëriform, or gaseous; they are all *ponderable*, and are subject to the agencies of light, heat, and electricity, which are imponderable. The ponderable elements are capable of uniting in various ways to form a great number of compounds, and these compounds in their turn are capable of uniting with each other to form a greater number of complex compounds, and so far as the knowledge of the experimental chemist extends, it leads him to consider that